Students: Louisa A. Avellar (UCB), Mircea Badescu, Stewart Sherrit, Yoseph Bar-Cohen, and Wayne Zimmerman of Caltech
Research Project Title: Pneumatic Sample Acquisition and Transfer System
Location: NASA’s Jet Propulsion Laboratory, Pasadena, California

Abstract:

Student: Stephanie Chang
Professor/Sponsor: Professor Alice Agogino
Mentor: Euiyoung Kim
Research Project Title: Establishing User Spaces in Medical Exoskeleton

Abstract:
As exoskeleton technology matures and becomes increasingly commercialized, the user spectrum of such technologies need to be identified and studied. This project examines exoskeleton technology from a human centric standpoint, establishing a comprehensive range of users for such products. In order to establish context to create a spectrum of exoskeleton users, literature was collected and reviewed to discover what exoskeleton researchers identify as their target users. The functionality of different types of exoskeletons are also identified and categorized and then matched up to potential user needs from different personas. From the literature review, different categorical spectrums are established to represent the range of users who would make use of exoskeleton technologies. Examples of spectrums include age, physical age, familiarity with advance technology, etc. In addition, further research into socially sustainable assistive technologies are identified and matched up to corresponding user personas and needs.

Students: Andrew Kooker and Casey Duckering
Professor/Sponsor: Professor Robert Full
Mentor: Chen Li
Sub Area: Mechatronics
Research Project Title: Micro-Robot with Ambulating and Jumping Abilities: A modification of the Biomimetic Millisystems Lab robotics for testing and analysis on animal locomotion processes

Abstract:
The goal of this project is to create micro-robots that can simulate standard insect/animal motions such as walking and running while being able to jump over encountered obstacles. The simulation of jumping mechanisms found in nature on fully mechanical robots can be used to better understand how and why they are used. Designs for robots can be created by understanding the dynamic effects of a jumping ability on motion when encountering obstacles, and simulating them effectively.

The initial step of our project dealt with simulating the simple motion of jumping on micro-robots that could already walk and run. It was important to analyze different methods of jumping from quick
actuation to elastic storage; for the ability to continuously jump on command, the method of quick actuation seemed ideal. We created an actuating hinge mechanism in SolidWorks and developed the basic skeletal models for the robot in AutoCAD. By using rapid-prototyping techniques such as 3D printing and laser cutting, we were able to quickly bring these computer renditions to life for physical testing. We integrated mechanical and electrical components like gearing systems and microcontrollers for actuation, and combined these assemblies with the base-skeleton of our robot. After writing software to test the system, we analyzed the effectiveness of our design based on the robot performance and developed a second iteration of the robot accordingly.

Throughout the design process, we were required to focus on key decisions like material choice, specific component purchases, and overall integration methods. We developed many iterations of software to efficiently test the robots, and made many design changes to the jumping mechanism and robot body itself. We were also able to learn principles of re-design by taking already-developed robotic components from the Biomimetic Millisystems Lab, and further modifying them to fit our needs.

We compared the effectiveness of our designs among iterations, and mapped out performance goals for future generations of the robots. We plan to continue modifying current robot designs and creating custom completely new designs for jumping-specific robots in the future. We also hope to continue the development of unique electronic components and software to seamlessly integrate with our mechanical robots.

**Student: Ryan Liu**  
**Professor/Sponsor: Professor Dennis Lieu**  
**Research Project Title: Protocol for Ballistics Lab Data Collection**

**Abstract:**  
Professor Lieu's research lab aims to improve the safety. In an effort to reduce long-term sustained injury from non-lethal weaponry, research was undertaken to investigate a new type of kinetic energy projectile. The projectile is similar in shape and energy transfer to currently used commercial non-lethal projectiles, but is made of a highly deformable, hyper-elastic, modified silicon rubber. Tests were conducted analytically using ABAQUS (FEA) and experimentally inside the UC Berkeley ballistics test lab. This report outlines the protocol necessary to perform ballistics lab work, which may be useful for both new ballistics lab researchers and for researchers at other laboratories alike.

**Student: Nicholas Anthony Renda**  
**Professor/Sponsor: Professor Dennis Lieu**  
**Mentor: Daniel Talancon**  
**Research Project Title: INSTAR RP-1: Development and Testing of an Electric Vehicle KERS Platform**

**Abstract:**  
My research this semester focused on creating a robust mounting solution for a flywheel-based energy storage system as part of the INertial STorage And Recovery (INSTAR) Lab. The flywheel is part of a Kinetic Energy Recovery System (KERS) on an electric go-kart, for the purpose of regenerative braking. The flywheel mount is designed to support the flywheel under extreme driving loads (cornering, braking, accelerating), while simultaneously damping vibrations through the use of rubber isolators. The flywheel
spins up to 25,000 rpm, so special care is taken to isolate all vibrations between it and the go-kart chassis.

The mount is made of 6061-T6 aluminum billet, and was designed to be manufactured almost entirely on a waterjet machine through the use of 2d profile parts. Bolt holes were postdrilled on a drill press to ensure tight tolerances. Rubber isolators embedded in the mounting plate damp vibrations and react shear loads to the chassis. A containment system was also designed to account for special load cases, such as flywheel seizure. In this load case, the rotating steel mass stops in less than 2 rotations due to debris in the bearing or an external impact. This imparts a massive torque on the mount, which begins to rotate and shears through the rubber isolators. It then comes in contact with the containment brackets, which are designed to take the load of a seizure impact without failing.

The go-kart was tested without the flywheel to ensure proper function of all other systems, including batteries, steering, brakes, motors, pedals, and electronics. INSTAR met its goal of a fully functional kart by Cal Day, having debugged code and designed new batteries and pedals to accomplish this task. The vehicle systems were then thoroughly tested to ensure sturdiness during multiple cycles of high-intensity accelerating and braking.

Student: Hale Reynolds
Course Project: ME 102B
Research Project Title: "Smart" Energy Harvesting and Usage as Applied to a Bicycle Light

Abstract:
For this project, a standard battery powered Light Emitting Diode (LED) bicycle light was modified, allowing it to harvest and store all the energy required for its use.

When normally operated, the bicycle light used for this project requires four AA batteries, located in a compartment just behind the circuit board holding the LEDs, and normally operates for around nine hours before the batteries must be replaced. The batteries were removed and replaced with a coin-sized rechargeable Lithium-Ion Battery (LIB), and circuitry governing the storage and usage of the generated electricity. (The LIB and circuit take up the same space as the four AA batteries.)

To generate electricity from the normal usage of the bicycle, very strong magnets (Neodymium magnets with residual flux density of 14.7 KGs) were mechanically fixed to the spokes in a similar fashion to the typical attachment of bicycle speedometer magnets. Then a tightly wound, fine copper wire coil was attached to the bicycle fork at the location where the magnets attached to the spokes would pass. As the magnets pass the copper coil, their magnetic field induces a potential difference across the coil ends. This voltage potential then drives the flow of current through wires run along the bicycle frame to the battery compartment. Before reaching the battery, the current must pass through series of four diodes arranged as a full-wave rectifier to ensure that regardless of the direction of the magnet rotation and regardless of the magnet polarity orientation, the electricity serves to charge the battery. To govern the usage of the charge stored in the battery, a simple control circuit was designed. For daytime operation of the bicycle, when it is light out, the generator charges the battery. Because no additional light is needed when it is bright out, the battery stores its charge and does not power the LEDs. For night riding or in other dark conditions, it is desired that the LEDs be powered to illuminate the cyclist's way. This photosensitive functionality was achieved using two transistors, an operational amplifier, a photosensor, and a series of resistors.
The circuit governing the use of the battery's charge is a small photosensor interfaced with an operational amplifier which was then connected to a CMOS Inverter (composed of the two transistors, one N-Channel and one P-Channel). If the output from the photosensor is high (light is incident upon it), this signal is amplified by the operational amplifier and the inverter allows no current to pass from the battery to the LEDs of the bicycle light. If the output from the photosensor is low (no light is incident upon it), this signal is still amplified by the operational amplifier, but if it is low enough, the inverter allows all the required current for full LED brightness to pass to the LEDs of the bicycle light. The resistors are used in balancing the operational amplifier, effectively calibrating the system. With the proper resistor combination, the circuit was calibrated to have the inverter transition between states at the proper, practical light intensities for day and night bicycling.

Key Points:
Through the use of this device, rather than replace four AA batteries after every nine hours of use, a smaller battery may be used to store energy generated from the normal use of the bicycle, and does not need replacing. It was found that during normal usage of the bicycle, 40% of the energy consumed from full-brightness bicycle-light use could be generated. This means that when it is bright out, and the bicycle light is off, the battery is easily charged, while at night the battery life is greatly extended. Although the energy produced by this device comes from the energy supplied by the rider, because there is no contact between moving components, and because the power generated is relatively small, there is no noticeable drag on the wheel due to energy generation. Also, in-terms of cost, the total cost of this project was much less than for a high-end bicycle light.

Students: Aliakbar Toghyan and Borna Dehghani
Professor/Sponsor: Professor Alice Agogino
Mentor: Kyunam Kim
Sub Area: Controls
Research Project Title: Tensegrity Robot

Abstract:
Soft robotics and tensegrities are the new chapters to the world of robotics. The term "Tensegrity" is a combination of the words "Tensile" and "Integrity", and it represents any structure consisting of elements that are only under tension or compression. The main objective of the Tensegrity research was to come up with a relatively low-cost but appropriate representative of NASA’s future explorer SUPERball. The purpose of making the early prototype was the initial approval of the control algorithm used for the movement of the robot, since the process of making the actual prototype in NASA is overly expensive and time consuming.

The robot consists of six rods that are connected by 24 elastic elements and it is formed into a sphere like configuration. The sphere would be able to roll by means of actuating the elastic components. As a team member I focused on designing a control algorithm for the robot. Based on simulation of the robot in Matlab, I found the optimized control algorithm for certain movements. Afterwards, I implemented the control system in the prototype and made sure that the robot had the desired motion.

Students: Lee Weinstein and Martin Cacan
Lab: Berkeley Manufacturing Institute
Research Project Title: Battery-Replacement Scale Energy Harvesting From HVAC Flows

Abstract:
The objective of the project is to create an energy scavenging device that produces over 100 μW of power in air flows of 2-5 m/s. These operating conditions are characteristic of HVAC systems, and the power output would be sufficient to run a low-power wireless sensor node at ~1% duty cycle.

The approach we have pursued is using a cylindrical obstacle inside an HVAC flow to trip vortex shedding. A fin attached to a piezoelectric bender vibrates and harvests energy as a result of an oscillatory pressure differential caused by periodic vortex shedding off of the obstacle.

An image and a few more details are available on our lab website: http://bmi.berkeley.edu/HVAC